BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

SUBJECT: Mission Sequence Plan for a Multi-Disciplinary Earth Orbital Space Station - A Preliminary Report. Case 720

DATE: December 27, 1968

FROM: S. L. Penn

TECHNICAL MEMORANDUM

I. INTRODUCTION

This memorandum attempts to answer questions regarding the practicality of a multi-disciplinary, earth orbital, advanced manned mission; e.g., are the expected day-to-day demands on spacecraft and crew reasonable? are there any fundamental incompatibilities between the requirements of the various disciplines? and can such a mission comfortably handle off-nominal as well as nominal situations and, if so, how? The mission concept and operational framework is described in Reference 1. Critical assumptions and guidelines are restated in Section II of this paper.

The approach is, first, to summarize and discuss the principal operational and experimental disciplines (based on their descriptions in drafts of corresponding memoranda, being prepared by the author and co-workers[2-7]) and, then, to present the disciplines in chart format as subsequences in an overall sequence plan of a nominal day.* In the chart the subsequences are shown to be a compatible, parallel and series, progression of events and activities, or modes. Sufficient uncommitted crew time is seen to exist to deal with contingencies as they arise, with minimum impact to activities requiring continuity.

The memorandum does not deal with the tasks of flight support, rendezvous, station assembly and preparation, logistics resupply, etc. Rather, it confines its attention to the conduct of the experiment performance part of the mission.

---

*To facilitate this time-line type presentation, in the referenced studies each technical discipline is treated as a package of experiments that could be run in a coordinated manner rather than as assemblies of individual, independent experiments.

(NASA-CR-103981) MISSION SEQUENCE PLAN FOR A MULTI-DISCIPLINARY EARTH ORBITAL SPACE STATION, A PRELIMINARY REPORT TECHNICAL MEMORANDUM, 27 DEC. 1968 (Bellcomm, Inc.) 18 p

N79-71613

Unclas

00/12 11529

FF No. 602

CR-103981

(NASA CR OR TMX OR AD NUMBER) (CATEGORY)

[redacted]

II. ASSUMPTIONS

The configuration baseline for the study is a loose interpretation of the Saturn V, B-2 Workshop(8) (the structure, e.g., SIVB tank, integral, modular, etc., is immaterial). Included are: a crew of six; an approximately 90-day logistics cycle for resupply, experiment change, data return, and, possibly, crew rotation; and separately gimballed astronomy and earth-looking experiment packages, for pointing generally independent of spacecraft attitude. It was also assumed, as per the referenced Workshop study, that these packages operate in pressurizable compartments so that EVA is not required for maintenance or service.

The experiments payload is of "intermediate" to "large" size(8). A separate guideline for this study directed that the experiment systems be heavily automated to obtain a large experimental return per astronaut man-hour.

III. SUBSEQUENCES

The subsequences of which the mission consists are: Operations and Maintenance, Astronomy, Earth Looking, Biomedicine, Bioscience, and Personal Maintenance. A remaining category titled Other Science and Technology represents the opportunity for additional experiment activities (or for rest and recreation) to be performed during the unscheduled time in the nominal day. The subsequences are reviewed briefly below. For more detail the reader is referred to the pending memoranda.

Operations and Maintenance (2)

For this study, space operations is defined in a limited way. Normally included maneuvering and habitability preparations would not be involved in the part of the mission under consideration. Experiment and personal activities are treated separately. Operations would consist, basically, of automatic control of system status to keep it within nominal limits, automatic monitoring to check system performance and warn of malfunctions or danger, and an occasional manual inspection of the spacecraft and instruments, which might be discontinued if system confidence grew to warrant it. Extensive demands of the crew in this subsequence would only be made in emergency situations. Maintenance, while off-nominal to the extent that it is unscheduled, takes on more than ordinary significance, since the concept of being able to make necessary replacements or repairs is the assumed approach to extended and reliable manned flights. Safety critical features would be redundant[8], so emergencies due to malfunctions should be rare. For timelining, minor repairs to experiment hardware are handled formally within the time allotted to the concerned subsequences. Major repairs of experiments on the whole system level and repairs of operational equipment would be handled as an off-nominal mode within this subsequence.

Astronomy[3]

This subsequence consists of parallel solar, stellar, and x-ray/gamma ray survey (EMR) operations. The latter two are primarily automated, and the former alternates between automated patrol modes and manned, high data rate observations of selected solar features. EVA examination of the equipment was thought desirable for its potential enhancement of the reliability and long term high performance of the system (particularly if IVA service, as planned for this mission, is not possible). In any case, by the 1975 time period an experimental EVA capability should be available, so that occasional examination of astronomy experiment equipment is possible.

Earth Looking[4]

This category includes earth sciences and applications in the broadest sense, i.e., all earth directed instruments. It is seen as an essentially automatic or ground programmed multi-instrument activity, with manned support for service, performance check, and special target selection. The instruments and tests in operation at any particular time would depend strongly on the ground track, the sun angle, and the weather. Instantaneous data generation rates during photography would be very large, but transmission rates to earth will be kept within reasonable limits by data selection and delayed hard data return (discussed further in Section IV under Resource Requirements).

Biomedicine[5]

Biomedicine is seen as the performance on each astronaut of the tests necessary to determine his physiological and behavioral adaptation to the space environment and to predict his ability to operate successfully in that environment for the duration of the current and extended missions and during the reentry phase of the current mission. There would be one medical experimentation period of 4-1/2 hours per day for each two astronauts,* who would alternately participate as subject and observer, and one of whom would also perform any necessary sample analysis. The conduct of the experiments, which need not be the same from day to day, will be facilitated by an Integrated Medical Behavioral Laboratory Measurement System (IMBLMS), a self contained, modularized package of experiments and measurement equipment.

The medical tests are, among other things, intended to assist in identifying illness or deconditioning. If a man is so afflicted as to be incapable of work, then the active biomedical mode in which he would serve as subject is replaced in the time line by an inactive mode. His duties as observer or laboratory technician can generally be picked up by someone else. The main time line impact of an afflicted astronaut will be reflected by changes in the Personal Maintenance subsequence, where astronaut availability for work is determined.

Bioscience[(6)]

Bioscience activities will include animal, insect, plant, and exobiology experiments. The animals will enable extended duration zero-g adaptability tests and the development of general surgical procedures for emergency use in space. The IMBLMS is a major hardware item here, too. The exobiology tests are seen as developing advanced, sterile space laboratory techniques for examination, for life forms, of extraterrestrial material (as might be recovered from meteorites, the Moon, or, ultimately, planetary probes).

Personal Maintenance[(7)]

Personal Maintenance is the key subsequence in that it determines when the other subsequences have manpower available for their support. The Personal Maintenance subsequence requires a schedule framework within which the crew's personal activities--sleeping, eating, hygiene, exercise, recreation, etc., --and work tasks can be most readily performed. For the purpose of drafting

*One may wish to quarrel with the amount of time set aside for medical experiments on a daily basis. However, the indicated request is consistent with current space medicine (NASA/MM) thinking, and can be further supported by desensitizing the time line. For instance, we may assume that a substantial biotechnology/human engineering/EVA effort may occupy this time as individuals or the entire crew are released from intensive medical surveillance.

this schedule, it is assumed that a multi-disciplinary mission will be most responsive to all its goals if it is planned for 24 hours a day operation with round-the-clock (though not continuous) manned participation. This is accommodated by a three shift day,with four of the six astronauts awake and two sleeping on each shift. Figure 1 (from Reference 7) shows what such a day might look like.

From the Figure it is seen that each shift repeats the same three modes as the preceding shift: a two hour period of Average (intermediate) Personal Maintenance, when two men are available for work; a four hour period of Minimum Personal Maintenance, when four are available; and a two hour period of Maximum Personal Maintenance, when none are. This variation in the available manpower enables expected fluctuations from the normal level of work activity to be fitted into the schedule. The long four-man work period is achieved in each shift by staggering each astronaut's day in much the same way as a working day on earth, even to the point of having less time between breakfast and lunch than between lunch and dinner.

The two hour periods designated "Work or Rest and Recreation" are, for scheduling purposes, generally regarded as work time. They only serve the R&R function when the men are not needed for work or when they have not gotten sufficient R&R in between their assigned activities. As we shall see, rest and recreation is possible at other times, since the regular "Work" periods are not fully utilized and since, as Reference 7 points out, the eight hour "Sleep" period may be excessive

In the event that someone is too ill to work, modified Personal Maintenance modes go into effect during those periods when he ordinarily would have been available for work; but, unless he needs special care, this would not generally impact the modes of the other disciplines. The other astronauts, however, will have less time off while a man is sick and auxiliary experiments will have to be postponed.

Other Science and Technology

Otherwise unscheduled time is assigned to this subsequence. This "swing time" is available for irregularly scheduled activities, minor contingencies, rest and recreation, or additional experiments. The experiments could be physical science or technology types, with add-on equipment (supplied before launch or via logistic flights) or with already-on-board equipment. They could be preplanned or they could be generated in real- or near-real-time, by the astronauts or by ground based scientists.

IV. THE MISSION SEQUENCE

A Nominal Day

This section describes the construction of a nominal day's activity on a multi-disciplinary mission. It was arrived at by separately programming the several disciplines, combining these programs on one chart, seeing where the overlapping activities placed excessive demands on spacecraft resources, and iteratively manipulating the separate schedules (within bounds acceptable to the respective investigators) until an apparently feasible mission resulted.

Figure 2 shows the sequence plan that was developed. The subsequences are listed in the first column, their modes* in the next column, and the scheduling is detailed in the remainder of the chart. Shift, orbit, and hour designations are across the top. Crew, power, and bit rate resource requirements for each mode are at the right.

In the Figure, active modes are indicated by horizontal bars, and transitions from one mode to another by breaks in the bars. For manned modes, the number of participating crewmen is noted at the left end of the bars. Summed values of crew, power, and bit rate are shown along the bottom, and the expected resource availability at the bottom right. Separately delineated by cross hatched bars are activities which, while not expected to occur daily, are still regarded as nominal and, as the summed figures show, can still be accommodated; e.g., Specimen Analysis (5C) would occur about one to two days per week and Exobiology (5E) is seen as occuring for about seven to ten consecutive days per logistics cycle. The similarly indicated Other Science and Technology experiments (7A) could be worked in with them. Their absence would enable the Other Science and Technology series (7B), represented by shaded bars, to be performed or would simply provide free time. The dashed bars of 7A and 7B show when additional tasks of short duration or capable of interruption can be done, if desired. Assignment of those periods for work should be sensitive and subordinate to rest and recreation needs, however.

Certain aspects of this plan are seen to be rigid while others are more flexible. The Personal Maintenance schedule once chosen is preserved. The extended, routine operations requiring

*The referenced subsequence reports, from which much of the data in Figure 2 has been abstracted, each contain a chart summarizing modes of activity which may occur. The description of a mode includes frequency of occurrence and duration; a description of the functions and who performs them; crew, power, and data rate requirements; and factors which cause transitions from one mode to another. The scheduled modes (preceded by an "S" in Figure 2) usually occur daily, though some may be on a weekly or other basis. The unscheduled modes ("U" in Figure 2) have only their lack of programability in common and can result from desirable events, such as solar flares, to undesirable, but anticipated (hopefully) events, such as meteor punctures.

manned participation have to be carefully scheduled so as to fit with Personal Maintenance; e.g., the intervals between the Quiet Sun (2B) modes are 3,3, and then 4 orbits and can't be readily adjusted without impacting other manned activities. Also, the medical activity cannot be shifted to any meaningful degree.

Some of the activities shown can be conveniently shortened or lengthened, for technical or scheduling reasons. The indicated regular cycling of the automated modes is artificial. Clearly, Stellar, Operate (2G) need not result in uniformly long periods of operation with precisely regular interruptions for Stellar, Point and Check (2F). Showing it that way serves as a good point of departure for the more detailed planning that would follow were this particular mission to be adopted or developed further.

Less frequent or shorter operations may be shifted quite freely. Film Processing (2I) is a once a day item which can be readily moved around. Modified Watch (1B), required once each shift, may be satisfactorily performed at irregular rather than regular intervals, so long as a reasonable time between performances is observed. We may even find it convenient for the man on watch to tend to the animals (5B) when he arrives in their vicinity. Also, Astronomy's Stellar, Point and Check (2F) and Earth Looking's Manual (3C) and Calibrate (3D) can probably be performed on a less rigid scheduling basis than shown in the Figure. This would, at times, enable their being done consecutively by the same man, thereby avoiding inconvenient interruptions of other activities. In the same vein, if the Specimen Analysis (5C) mode could not be conveniently shortened (as shown in Figure 2, it has a 1/3 hour tail that conflicts with 2F), it could still be completed by dropping the concurrent 2F mode, postponing 2F to the next shift, or, perhaps, by having the man on Quiet Sun (2B) duty come down and perform 2F during a dark side pass.

Off-Nominal Periods

An off-nominal period is caused by the occurrence of any one or more unscheduled events (contingencies) capable of requiring a transition to any of the "U" modes on Figure 2. These events are not necessarily of an emergency nature, though they often require prompt attention to avoid degrading the mission. Thev cover a wide range of desirability and responses, for example: highly desired solar flares of importance 1-3, requiring prompt transitions to Flare (2D) mode if their study is to be effective; less desired, but expected, component failures, resulting in a more leisurely transfer, within certain constraints, to an appropriate repair mode such as Earth Looking's 3G or Biomedicine's 4C and completely undesired fires or meteor punctures, resulting in a major impact to many or all activities and an immediate transition to one of the emergency modes of Operations and Maintenance, namely Repair (Suited)(1F), Standby (1G), or Abort (1H). A list of possible contingencies is offered in Figure 3. The likelihood factors assigned are the author's best guess.

The rate of occurrence of off-nominal modes depends on the type of event causing them. Their impact on the nominal situation depends on how well their occurrence has been anticipated and whether the configuration and mission plan have been kept flexible enough to allow for their ready disposition. As an example, we consider the occurrence of solar flares. Any other contingencies of comparable frequencies would be similarly treated. If a flare should occur on either of the first two shifts during the Quiet Sun (2B) mode, which requires one-man participation, Figure 2 shows that, in view of the manpower available then, a transition to Flare (2D) mode, requiring two men, would be permitted. If a flare occurred in the third shift during 2B, a transition to 2D could still be accommodated by shifting Film Processing (2I), if it can be interrupted, or by terminating the medical activity (4A), if priorities permit.

Flares occurring early in the shift are generally accommodated without impact by delaying Modified Watch (1B) or other current short duration manned modes (the time for Earth Looking's Manual (3C) mode is critical only in the case of particular targets of opportunity, and animal feeding time (5B) is moderately flexible). This leaves for consideration the end of the shift, when the Maximum Personal Maintenance (6C) mode leaves no men "nominally" available for work.

As inferred from data in Reference 9, the occurrence of flares of importance 1 and up in 1973 (earliest date for the Saturn V Workshop study) is expected to be about once or twice a day, frequent enough to provide ample flares for study without disruption of 6C. However, major flares, of importance 2 and up, should only occur about once a week, and importance 3 and up flares about once a month. These rates will decrease significantly further to a minimum at the solar cycle low at mid-decade (a better date for the mission of this study). The chance, then, of a major flare (importance 2 and 3) occurring during and, hence, conflicting with a Maximum Personal Maintenance (6C) mode (which exists for 1/4 of every day) in a 1975 mission is less than once a month.* It would seem reasonable, therefore, to disrupt the personal maintenance activities of two of the four awake men in 6C for such an occurrence. It should be remembered, for this and other infrequent conflicts between pressing contingencies and the Maximum Personal Maintenance (6C) mode, that even though six astronauts are involved in 6C, and should be considered unavailable for routine activities, any number of them up to the full complement can be assigned to action commensurate with the circumstances.

---

*The joint probability of their occurrence on any one day were the mission to take place in 1973 is $1/4 \times 1/7 = 1/28$.

Without treating the subject in detail, the author estimates that the time-line-impact of maintenance activities will be less than that of solar flares on a 1973 mission. As argued below, the frequency may be on the order of once a week. Additionally, if a repair can not be conveniently attended to immediately, it will usually be possible to delay it until spare manpower is available. Reference 10 in its analysis of the maintainability of a long duration environmental control/life support system (EC/LSS) estimates the mean time between failure (MTBF) of components in the combined functional (EC/LSS) and fault detection system to be 392 hours, or about 16 days. Since the EC/LSS alone had an MTBF of 85 days, the fault detection system must have had an MTBF of 20 days (1/85 + 1/20 = 1/16). The writer, for a ballpark estimate, assumed the existence of about five operational (EC/LSS, Electric Power System, Data Management System, Communication System, and Attitude Control System) and three experimental (Astronomy, Earth Looking, and IMBLMS) major hardware systems of roughly equal complexity, giving them a joint MTBF of 85/8 = 11 days. Now, assuming that our fault detection system is a broadly applicable version of that of the reference, (but also more refined in order to have about the same MTBF), we have a joint MTBF of components for our mission of about seven days (8/85+1/20 = 1/7), or one week.*

Also from Reference 10, indications are that one hour should be adequate time in which to effect most repairs (component replacements). This being the case, Figure 2 enables us to see that we rarely have to delay a repair beyond the shift in which the failure occurs, if anybody is capable of performing it, nor more than a day, if only one of the crew has the necessary expertise. Again, in an emergency, the right man or men can be put on the job within, at most, the time necessary to wake up and become acquainted with the problem.

Resource Requirements

It is seen, from the summed data along the bottom of Figure 2 and from previous discussion, that the manpower regularly available for work on the assumed schedule should be adequate to handle all nominal and most off-nominal situations.

---

*In order to avoid an unacceptably high multiple failure rate, this MTBF may have to be considered a design minimum requirement. Note that two failures in one day might be expected every seven weeks and triple failures every year (49 weeks). This is not objectionable from a time-line point of view. A substantially higher rate would be.

Power requirements also fall within the 10 kilowatt capability expected to be developed for an S-V Workshop[8]. Usually, there is a kilowatt to spare, with little fluctuation about the average.*

The bit rate requirements deserve some special attention. It is assumed that as much data as possible will be transmitted down, partly to save return weight and minimize the risk of data loss, but mainly to give early insight into experiment results in order to maximize the principal investigator's ability to reprogram his experiment. The bit rates indicated on Figure 2 are preliminary estimates of the maximum sustained (say, for at least a minute) telemetered rates. These exceed the maximum sustained on-board electronic record rates, since transmission can only take place for a fraction of each orbit (assuming no synchronous satellite support) and recording can be continuous. If a telemetry capability of 20×10^6 bits per second (bps) is assumed**, the preliminary nature of the estimates in Figure 2 is not of much consequence. Errors of one to two orders of magnitude can be readily tolerated, with the exception of a few very high requirements (photographic) in the Astronomy and Earth Looking subsequences.

The exceptions referred to above are the 10^8 bps for the Active Sun (2C) and Flare (2D) modes of the Astronomy subsequence and the up to 2×10^9 bps for the Automatic (3B) and Manual (3C) modes of the Earth Looking subsequence. Reference 11 makes some very sound suggestions as to how the high data taking rates of these modes (due to their photographic nature) can be kept from forcing transmission requirements to exceed reasonable limits of, say, 20 Mbps. These techniques include the selection by the astronauts of the pictures or parts of pictures to be sent with high fidelity and the transmission of lower quality, TV facsimilies where this will do until the hard copy can be returned (about 90 days, max.).

---

*A detailed study with more emphasis on configuration and experiments would show structure in the power profile. Particularly if the experiments packages are manufactured as separate modules, it may be advantageous to supply power at a constant rate and use peaking batteries, if necessary, within the modules.

**1-20 Mbps, which would allow TV of almost commercial quality, has been considered a reasonable capability to build into an orbiting workshop in the 1970's[11].

V. SUMMARY AND CONCLUSIONS

The activities of a typical day on a multi-disciplinary, earth orbiting space station have been discussed and graphically described. The physical setting of the mission is a space station with independent experiment pointing capabilities and largely automated operations. A crew of six follows a three shift day of two men asleep and four awake at all times, to allow an approximately continuous level of productive activity. The latter consists of the automated and/or manual performance of several distinct groups of experiments, principally in the areas of astronomy, earth applications, biomedicine, and bioscience. The graphical sequence planning technique adopted has provided a useful way of organizing and collectively examining the various disciplines and their requirements. Further definition of the experiment disciplines is in progress and will be reported shortly.

The study suggests that whenever men are available for work one man should generally be kept free of "connected type" tasks (those which could be degraded by interruptions). This would allow his spot assignment to meet the numerous unscheduled events requiring additional manned attention and would free the other men from interruption when they are assigned to activities requiring continuity or regularity. The presented mission sequence plan has sufficient scheduling flexibility to permit the performance of a sizeable complement of preprogrammed experiments, a variety of planned, short duration tasks, and a reasonable number of anticipated contingency and emergency tasks. While no claim is made as to having presented the optimum way of running an earth orbital experiment program, this memorandum lends strong support to the feasibility and practicality of the selected mission and modus operandi.

ACKNOWLEDGEMENT

This paper has benefitted substantially from the referenced disciplinary studies of and discussions with the author's co-workers, N. Zill, W.W. Elam, D. B. Hoffman, R. E. McGaughy, and M. A. Robinson, and in particular from the support and criticism of G.T. Orrok, who also contributed many of the ideas related to the mission concept, the Other Science and Technology subsequence, the multiple failure rate analysis, and the chart on contingencies (Figure 3).

S. L. Penn

1011-SLP-sp S. L. Penn

Attachment
Figures 1 thru 3

REFERENCES

1. Orrok, G.T., "Introduction to a Study of Operations on a Multi-Disciplinary Space Station," Bellcomm TM-68-1011-11, December 27, 1968.

2. Penn, S.L., "Operations and Maintenance Subsequence for a Multi-Disciplinary Earth Orbital Space Station, Bellcomm TM-68-1011-13, December 31, 1968.

3. Zill, N., "Astronomy Subsequence in a Multi-Disciplinary Earth Orbital Space Station," Bellcomm TM-68-1011-5, December 27, 1968.

4. Elam, W.W., "Earth Looking Subsequence in a Multi-Disciplinary Earth Orbital Space Station," Bellcomm TM-68-1011-8, December 27, 1968.

5. McGaughy, R.E., "Biomedicine Subsequence for a Multi-Disciplinary Earth Orbital Space Station," Bellcomm TM-68-1011-6, December 27, 1968.

6. McGaughy, R.E., "Bioscience Subsequence in a Multi-Disciplinary Earth Orbital Space Station, Bellcomm TM-68-1011-7, December 27, 1968.

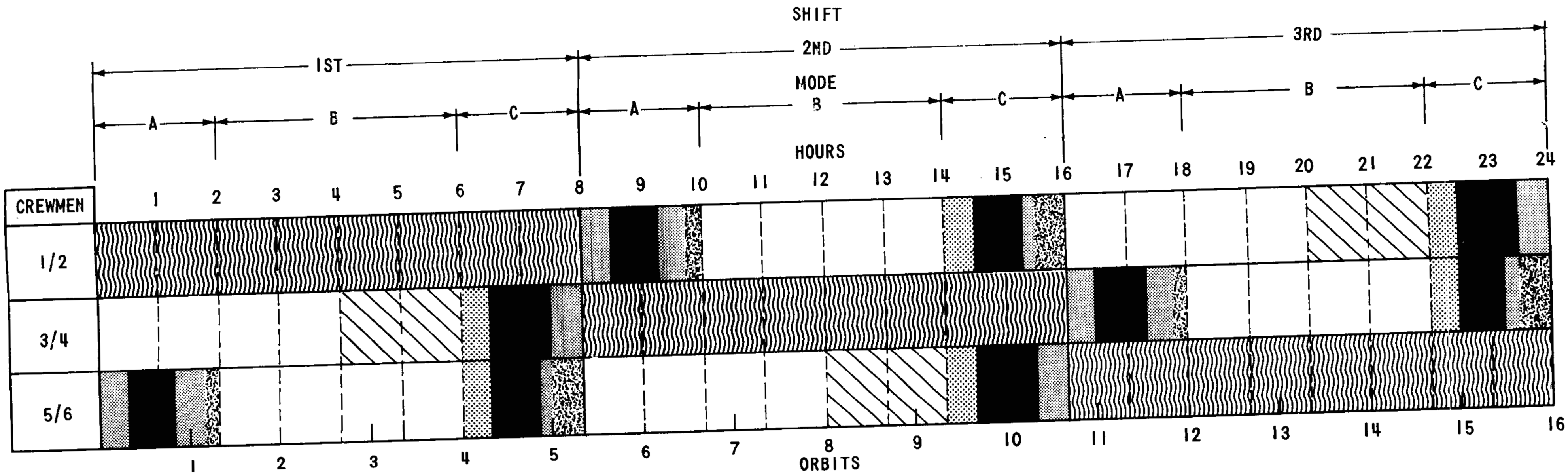
7. Penn, S.L., Robinson, M.A., "Personal Maintenance Subsequence for a Multi-Disciplinary Earth Orbital Space Station," Bellcomm TM-68-1011-10, December 27, 1968.

8. OMSF Planning Group, "Saturn V Workshop Study, Vol. II - Task Team Analysis," April 1, 1968.

9. de Gaston, A.N., "Relative Advantage of 50° and 28-1/2° Orbital Missions to ATM Solar Astronomy," Bellcomm Memorandum for File, June 10, 1968.

10. The Garrett Corp., "The Impact of Maintainability on the Design of Long Duration Life Support Systems," vu/graphs for NASA presentation of April 18, 1968.

11. Gruman, E.L., Liebowitz, B.H., Rocchio, J.J., Schaenman, P.S., "The Flow of Data in Advanced Manned Missions," Bellcomm Memorandum for File, March 17, 1967.



TYPICAL TIMELINE

SLEEP	8 HRS.
HYGIENE	1/2 HRS.
EAT	3/4 HRS.
HYGIENE	1/2 HRS.
HOUSEKEEP	1/4 HRS.
WORK	4 HRS.
EXERCISE	1/2 HRS.
EAT	3/4 HRS.
HYGIENE	1/4 HRS.
HOUSEKEEP	1/2 HRS.
WORK	4 HRS.
REST & RECR.	2 HRS.
EXERCISE	1/2 HRS.
EAT	1 HRS.
HYGIENE	1/2 HRS.
TOTAL	24 HRS.

MODE EXPLANATION

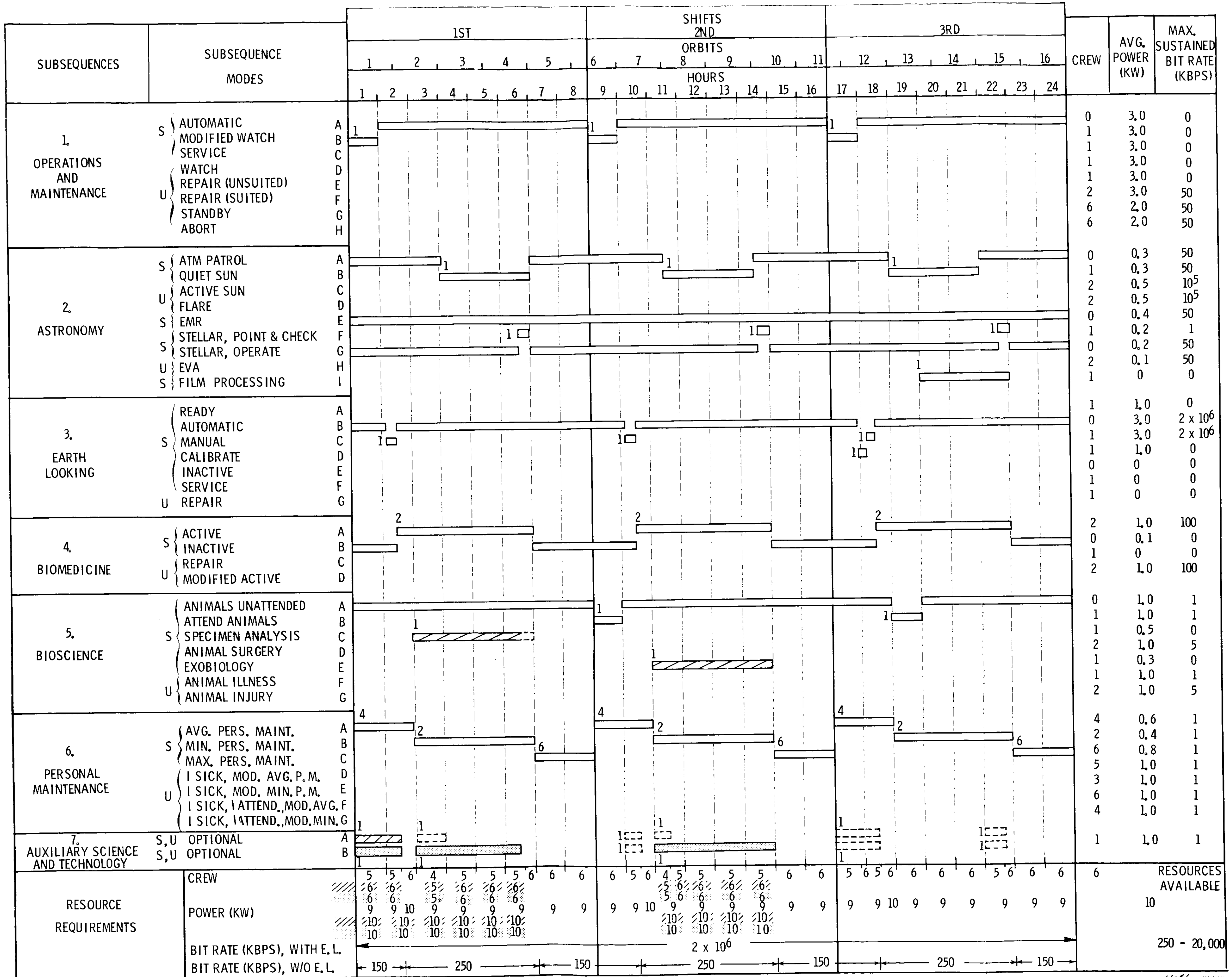
A AVERAGE PERSONAL MAINTENANCE
4 MEN IN P.M.; 2 AVAILABLE FOR WORK

B MINIMUM PERSONAL MAINTENANCE
2 MEN IN P.M.; 4 GENERALLY AVAILABLE FOR WORK

C MAXIMUM PERSONAL MAINTENANCE
6 MEN IN P.M.; NONE AVAILABLE FOR ROUTINE WORK

LEGEND

FIGURE 1 - CREW IN-FLIGHT PERSONAL MAINTENANCE SCHEDULE



ACTIVE MODE, x = NUMBER OF CREW PARTICIPATING

ADDITIONAL ACTIVITIES FOR A BUSY DAY: ////OR

THIS CHART IS BASED ON DRAFT DATA ON THE SEVERAL SUBSEQUENCES AND WILL DIFFER IN DETAILS FROM DATA IN THE FINAL MEMORANDA

FIGURE 2 - MISSION SEQUENCE PLAN FOR A MULTIDISCIPLINARY SPACE STATION - A NOMINAL DAY

FIGURE 3

SOME POSSIBLE CONTINGENCIES

CONTINGENCIES	RELATIVE LIKELIHOOD OF OCCURRENCE		
	HIGH	LOW	UNKNOWN
OPERATIONS AND MAINTENANCE			
COMPONENT FAILURES	X		
SYSTEM FAILURES (NOT READILY TRACEABLE TO COMPONENT)			X
AIRLOCK FAILURE		X	
SPIN (DUE TO ACS FAILURE)		X	
EXCESSIVE ATMOSPHERIC LEAKAGE			X
PLUMBING LEAKAGE (LOOSE LIQUID DEBRIS -HAZARDOUS, NONHAZARDOUS)			X
METEOR PUNCTURE		X	
INTERNALLY CAUSED PUNCTURE		X	
COLLISION WITH OTHER VEHICLES (E.G., FAILED DOCKING)		X	
FIRE		X	
CONTAMINATION OF ATMOSPHERE			X
EVA RESCUE		X	
RADIATION HAZARD (SOLAR FLARE OR HIGH ALTITUDE NUCLEAR TEST)		X	
WAR			X
ASTRONOMY			
SOLAR FLARE, CLASS 1,2,3	X		
LONGLIVED SOLAR ACTIVITY (EXTENDED MONITORING AND INSTRUMENT POINTING DESIRABLE)			X

FIGURE 3 (CONT'D)

SOME POSSIBLE CONTINGENCIES

CONTINGENCIES	RELATIVE LIKELIHOOD OF OCCURRENCE		
	HIGH	LOW	UNKNOWN
ASTRONOMY (CONTINUED)			
VERY LOW SOLAR ACTIVITY (DISK BLANK; INSTRUMENTS CHECK-OUT OK)			X
EMR UNUSUAL PHENOMENA (TRANSIENTS?)			X
STELLAR, PLANETARY SURPROSES (NOVA: WILL AUTOMATED DIRECTION BE ADEQUATE? - DEPENDS ON OBSERVING PROGRAM, ACCESSORIES AVAILABLE)			X
CONTROL SYSTEM FAILURE (DEGREE? REPAIRABLE? WORK AROUND?)			X
EARTH LOOKING			
STORM	X		
VOLCANIC ERUPTION			X
EARTHQUAKE			X
FIRES	X		
OTHER INTERESTING PHENOMENA	X		
BIOMEDICINE			
HARDWARE FAILURE (IMBLMS NOT AVAILABLE; REPAIRABLE)	X		
CONDITIONING OR HEALTH DECREMENT (OR INCREMENT) OBSERVED			X
NO TREND IN DATA			X
BIOSCIENCE			
BIOSCIENCE LAB LIFE SUPPORT FAILURE			X

FIGURE 3 (CONT'D)

SOME POSSIBLE CONTINGENCIES

CONTINGENCIES	RELATIVE LIKELIHOOD OF OCCURRENCE HIGH	LOW	UNKNOWN
BIOSCIENCE (CONTINUED)			
STRIKING EFFECTS OBSERVED			X
ANIMAL OR PLANT DIES (PUTRIFIES?)			X
LIFE APPARENTLY FOUND IN METEORIC SAMPLE (WHAT THEN?)		X	
ANIMAL LOOSE IN SPACECRAFT (FLYING? HIDDEN?)		X	
PERSONAL MAINTENANCE			
POOR PERFORMANCE (INCLUDES BEHAVIORAL PROBLEMS)			X
ILLNESS	X		
INJURY		X	
CONSUMABLE SPOILAGE		X	
ATTENTION DEMANDING EARTH EVENTS (E.G., WORLD SERIES)	X		
IN-FLIGHT TRAINING	X		

BELLCOMM, INC.

COVER SHEET FOR TECHNICAL MEMORANDUM

TITLE – Mission Sequence Plan for a Multi-Disciplinary Earth Orbital Space Station - A Preliminary Report.

TM-68-1011-9

FILING CASE NO(S) – 720

DATE – December 27, 1968

AUTHOR(S) – S. L. Penn

FILING SUBJECT(S) – (ASSIGNED BY AUTHOR(S) – Advanced Manned Mission Planning
Earth Orbital Space Station
Manned Multi-Disciplinary Space Station

ABSTRACT

The subject report provides an overview of the daily conduct of typical activities on a multi-disciplinary, earth orbital, advanced manned mission, the base line configuration for which is a loose interpretation of a Saturn V, B-2 Workshop. Preliminary descriptions of the principal operational and experimental disciplines are reviewed, and then presented graphically as a compatible, parallel and series, sequence of events and activities. Nominal and off-nominal operations are discussed. It is shown that a crew of six on a three shift day with two men asleep and four awake at all times will allow a relatively continuous level of scheduled, productive activity. This will also permit sufficient flexibility for the ready performance of a variety of unscheduled, including contingency, tasks as long as one of the men available for work is generally free of commitment to "connected type" activities.

SEE REVERSE SIDE FOR DISTRIBUTION LIST